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Relationships between clouds, SST & circulation over the tropical oceans

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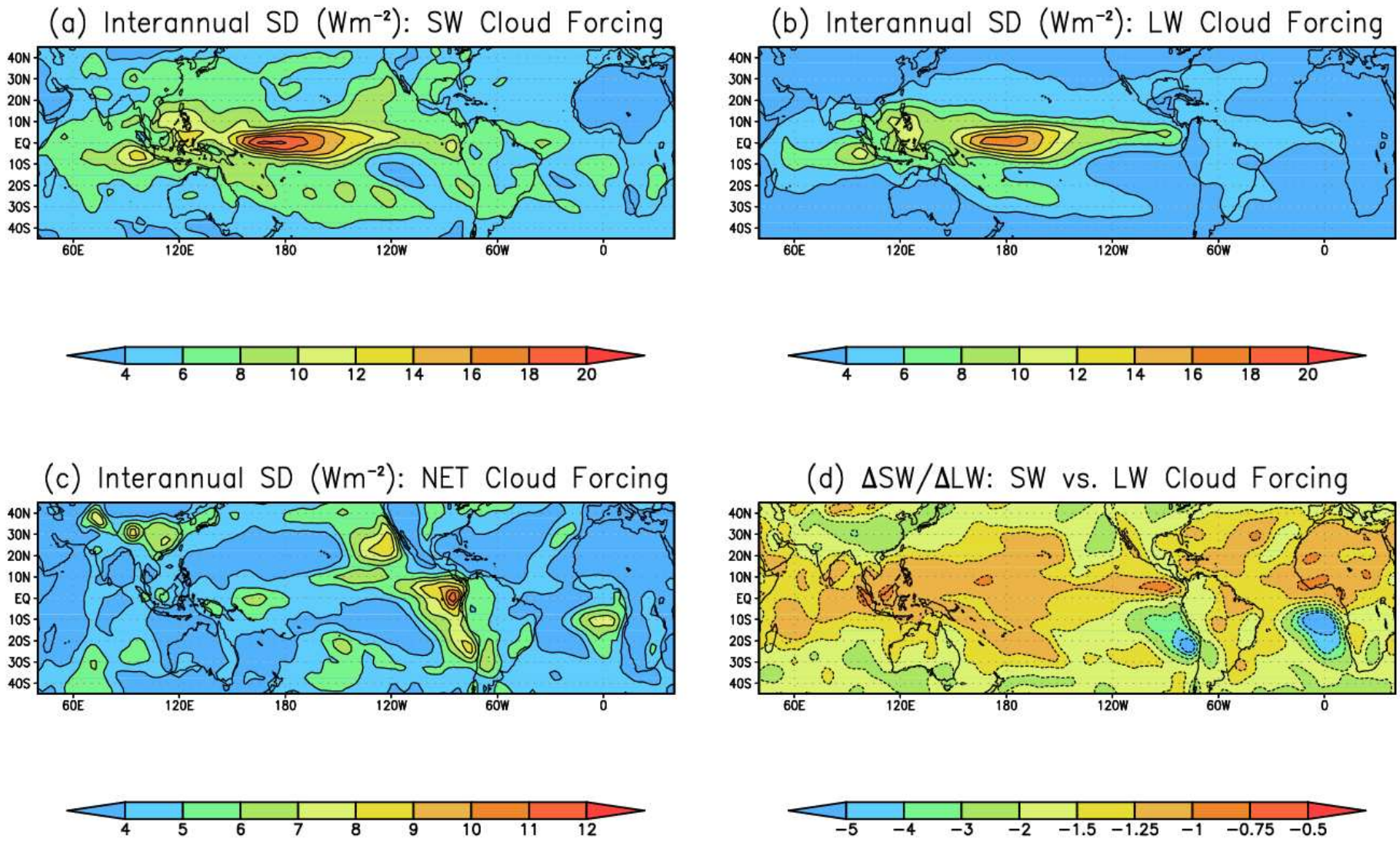
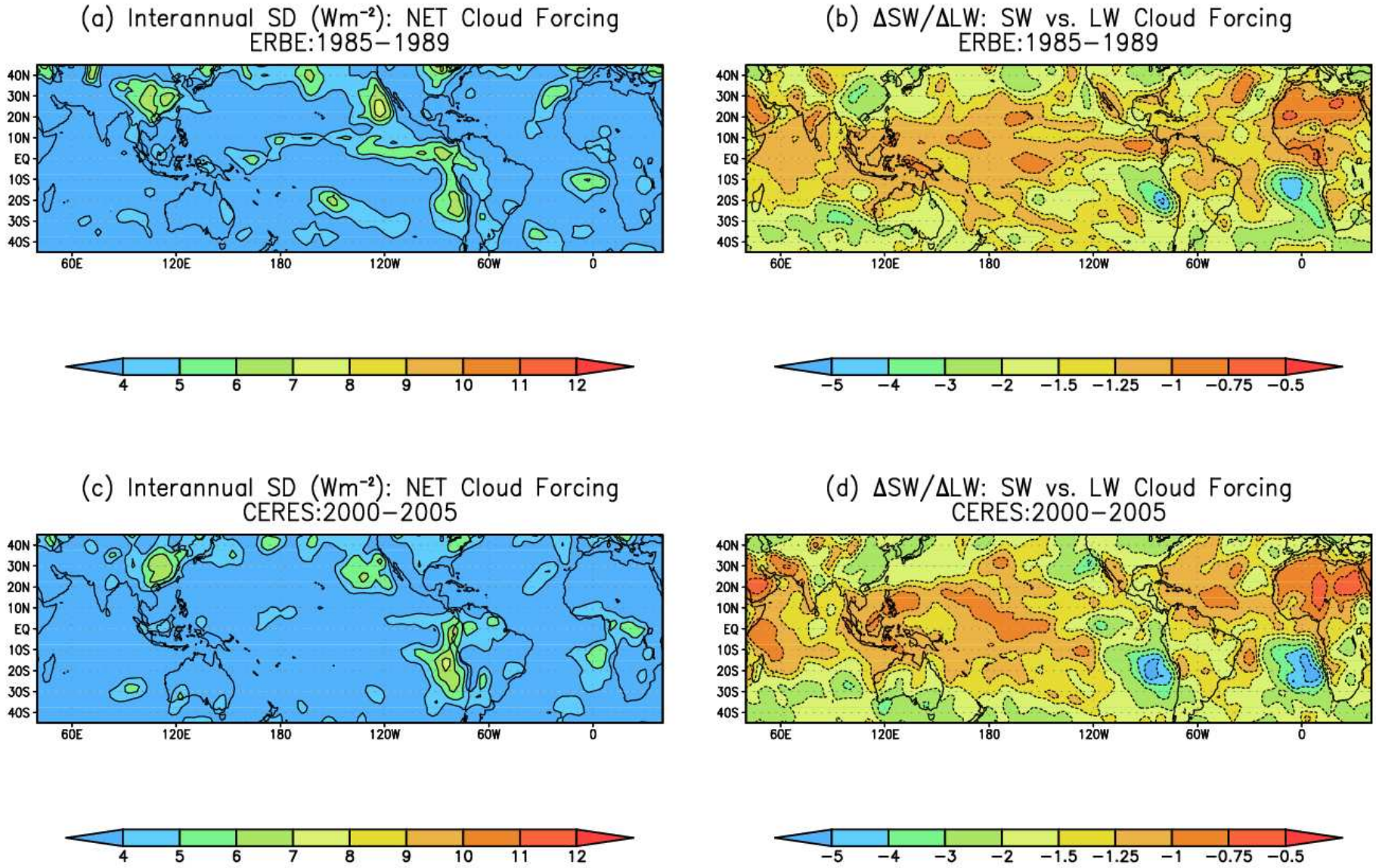
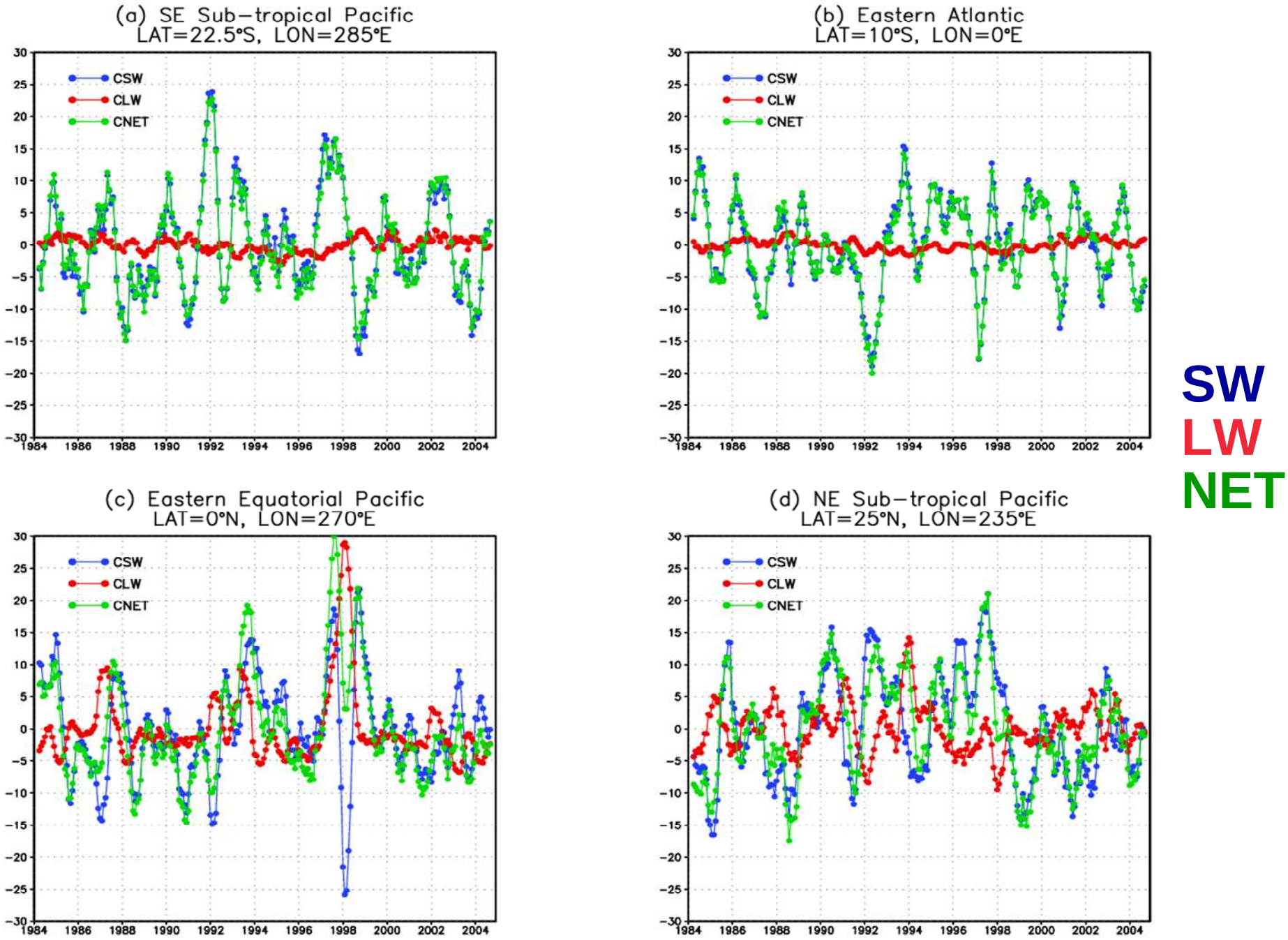
Interannual variability of cloud radiative forcing in the tropics



Derived from monthly mean anomalies of ISCCP-FD data: 1984 – 2004




(a) SE Sub−tropical Pacific
LAT=22.5°S, LON=285°E
(b) Eastern Atlantic
LAT=10°S, LON=0°E
(c) Eastern Equatorial Pacific
LAT=0°N, LON=270°E
(d) NE Sub−tropical Pacific
LAT=25°N, LON=235°E
CSW
CLW
CNET
SW
LW
NET

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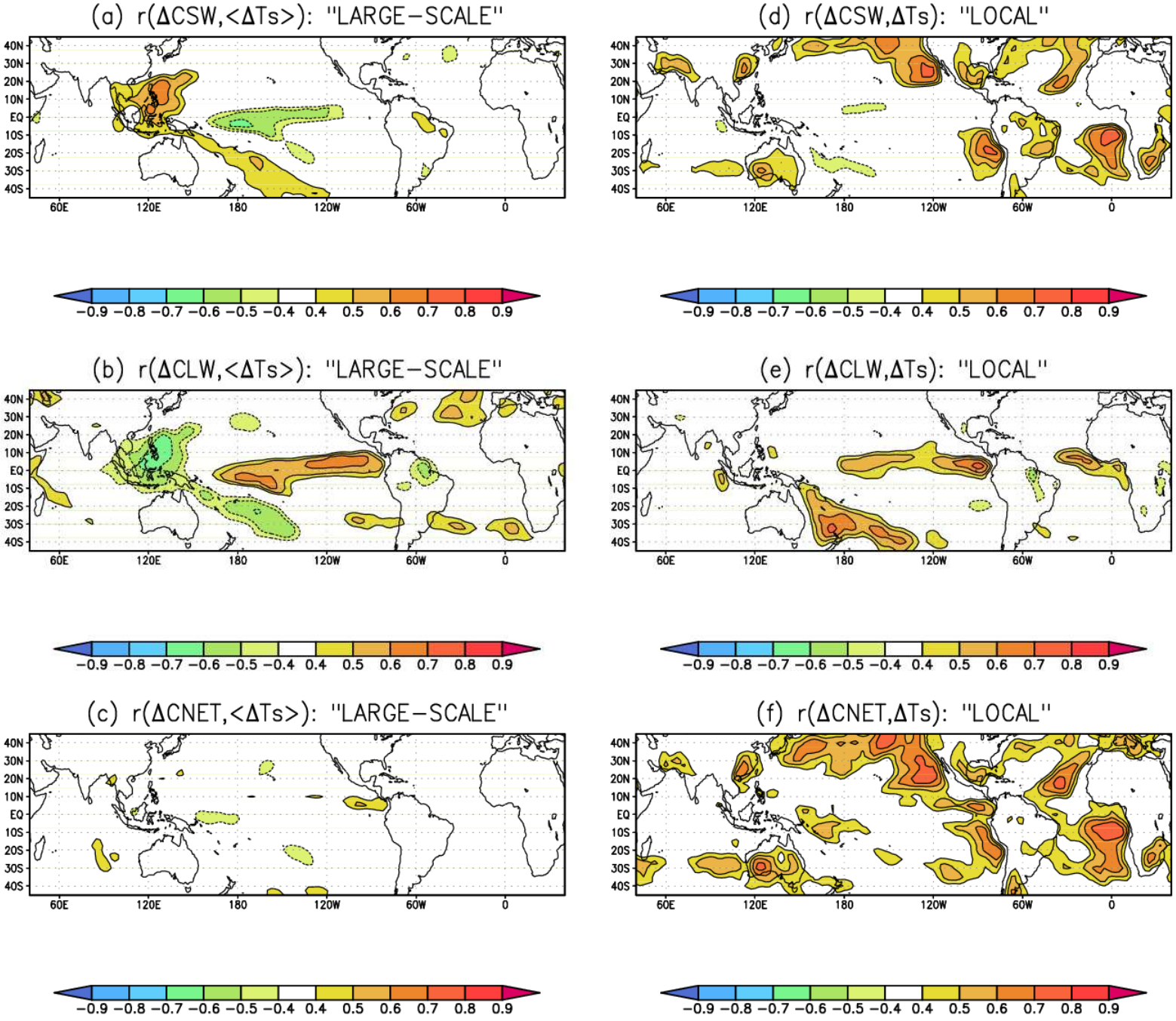
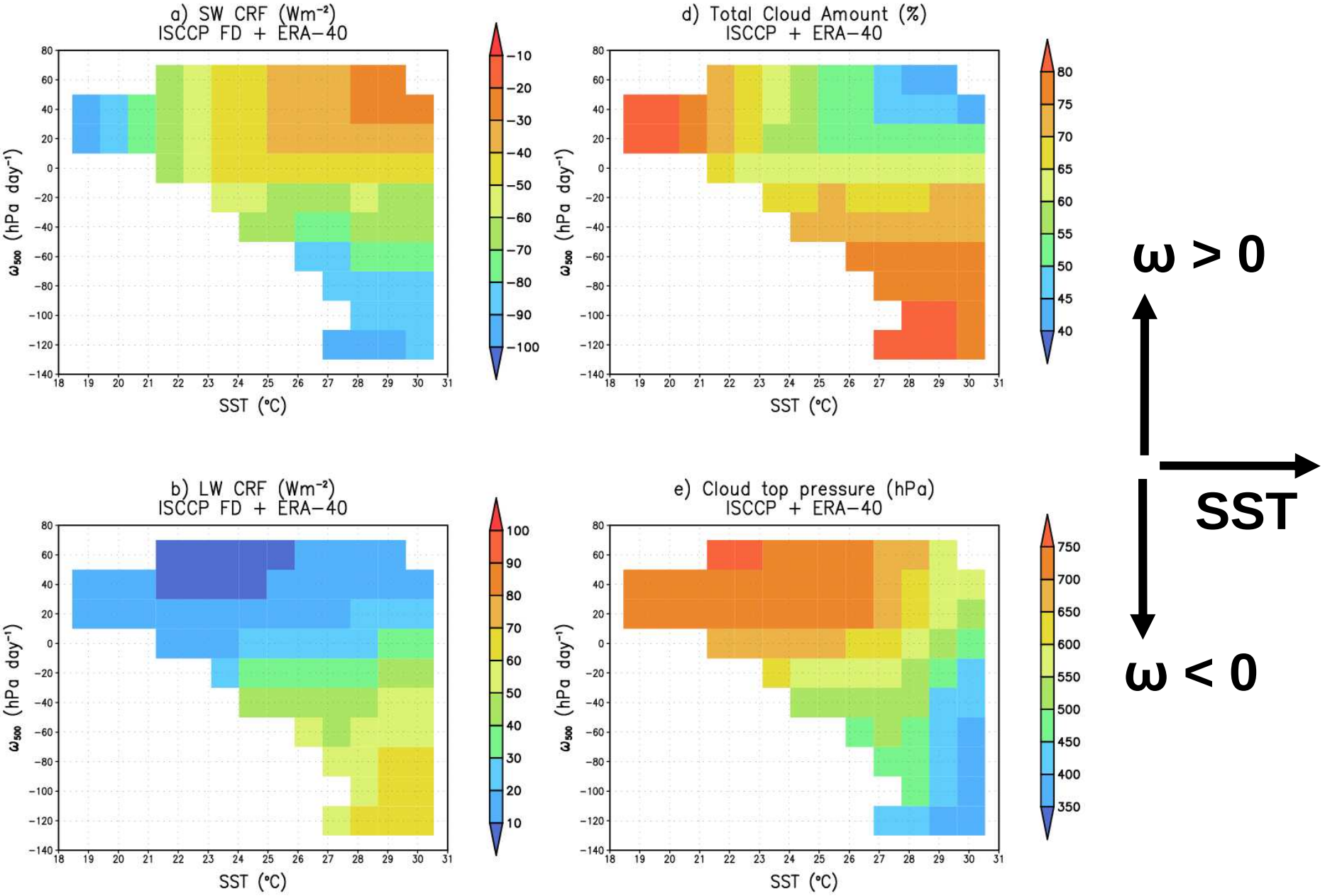
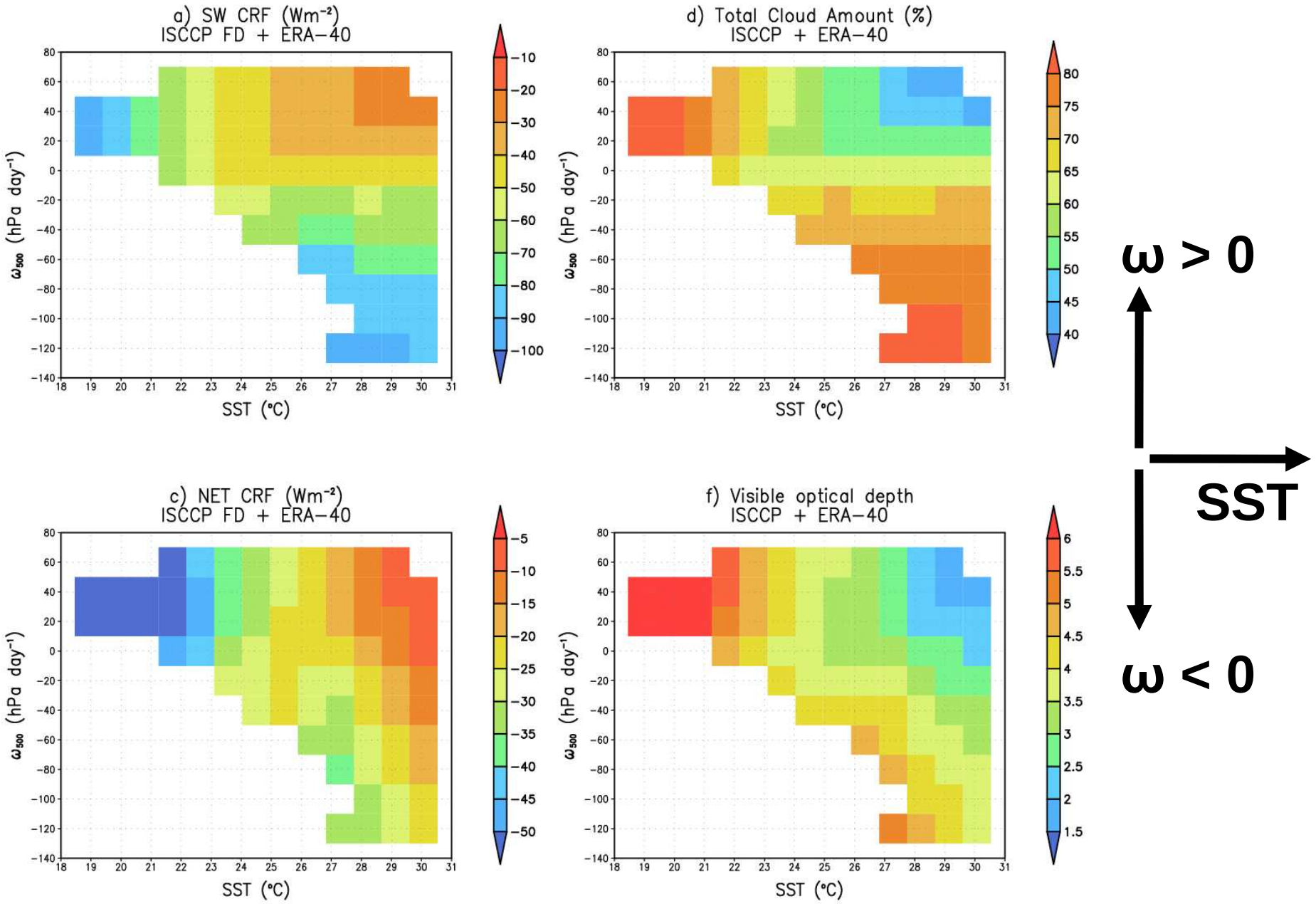
Relationships to SST and circulation


(a) r(ΔCSW,<ΔTs>): "LARGE−SCALE"
(d) r(ΔCSW,ΔTs): "LOCAL"
(b) r(ΔCLW,<ΔTs>): "LARGE−SCALE"
(e) r(ΔCLW,ΔTs): "LOCAL"
(c) r(ΔCNET,<ΔTs>): "LARGE−SCALE"
(f) r(ΔCNET,ΔTs): "LOCAL"
40N 30N 20N 10N EQ 10S 20S 30S 40S
60E 120E 180 120W 60W 0
−0.9 −0.8 −0.7 −0.6 −0.5 −0.4 0.4 0.5 0.6 0.7 0.8 0.9





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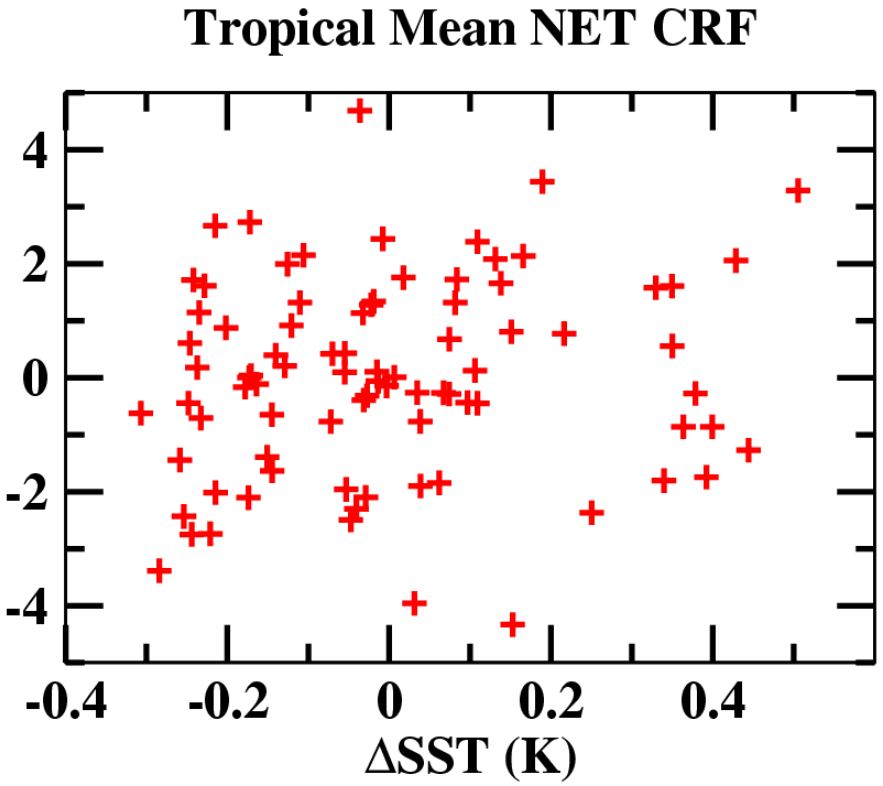
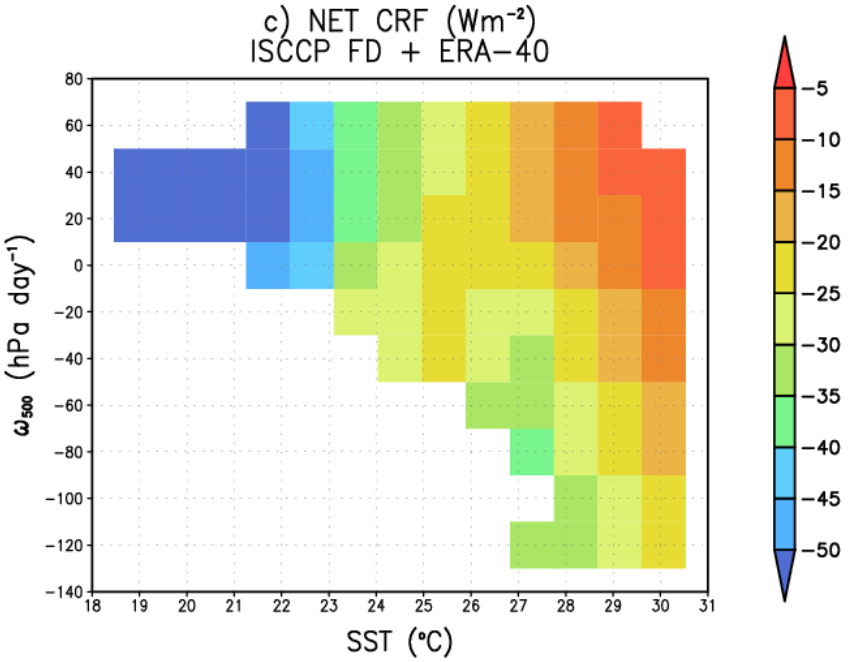
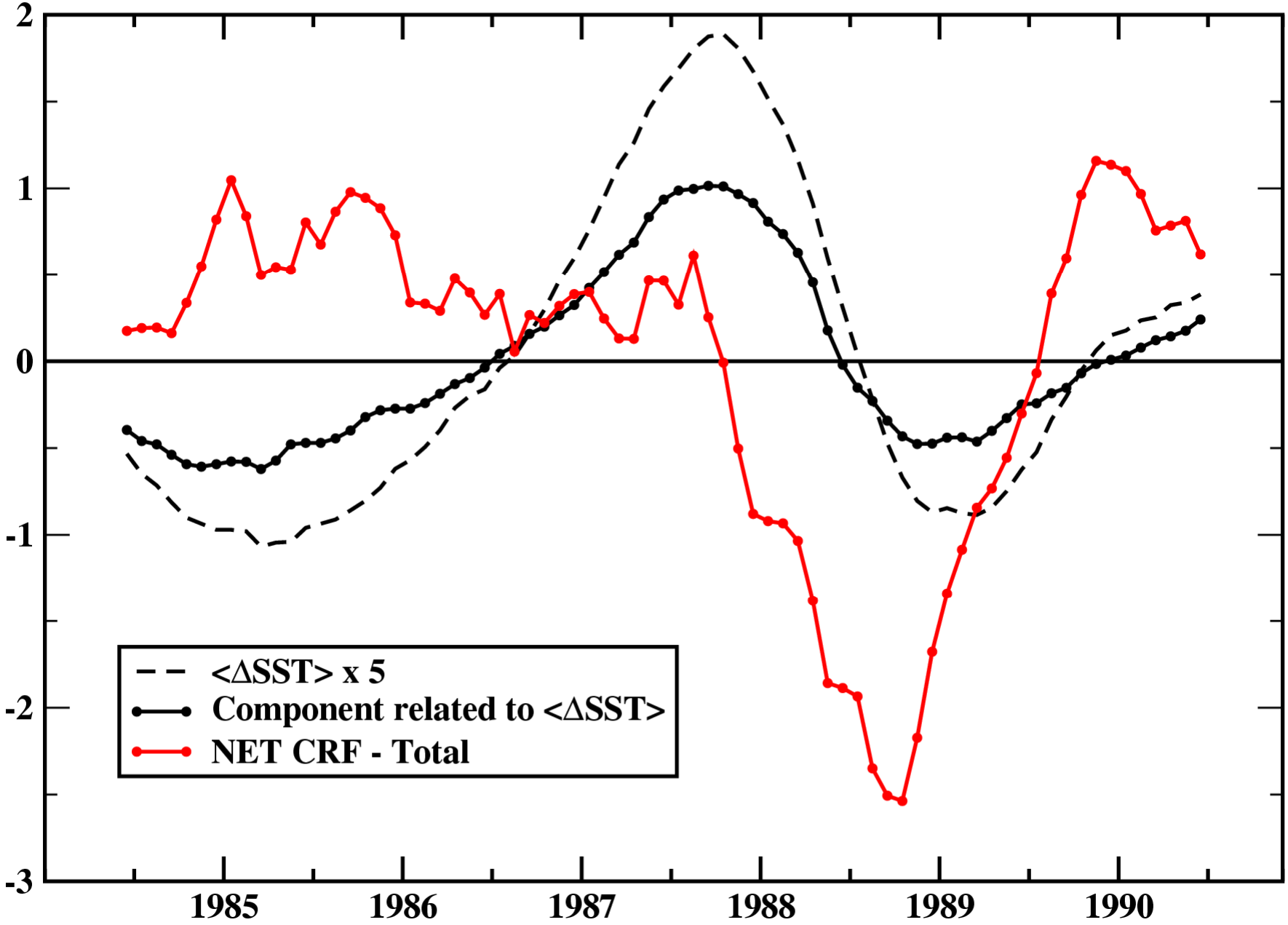
Variations in the tropical mean CRF

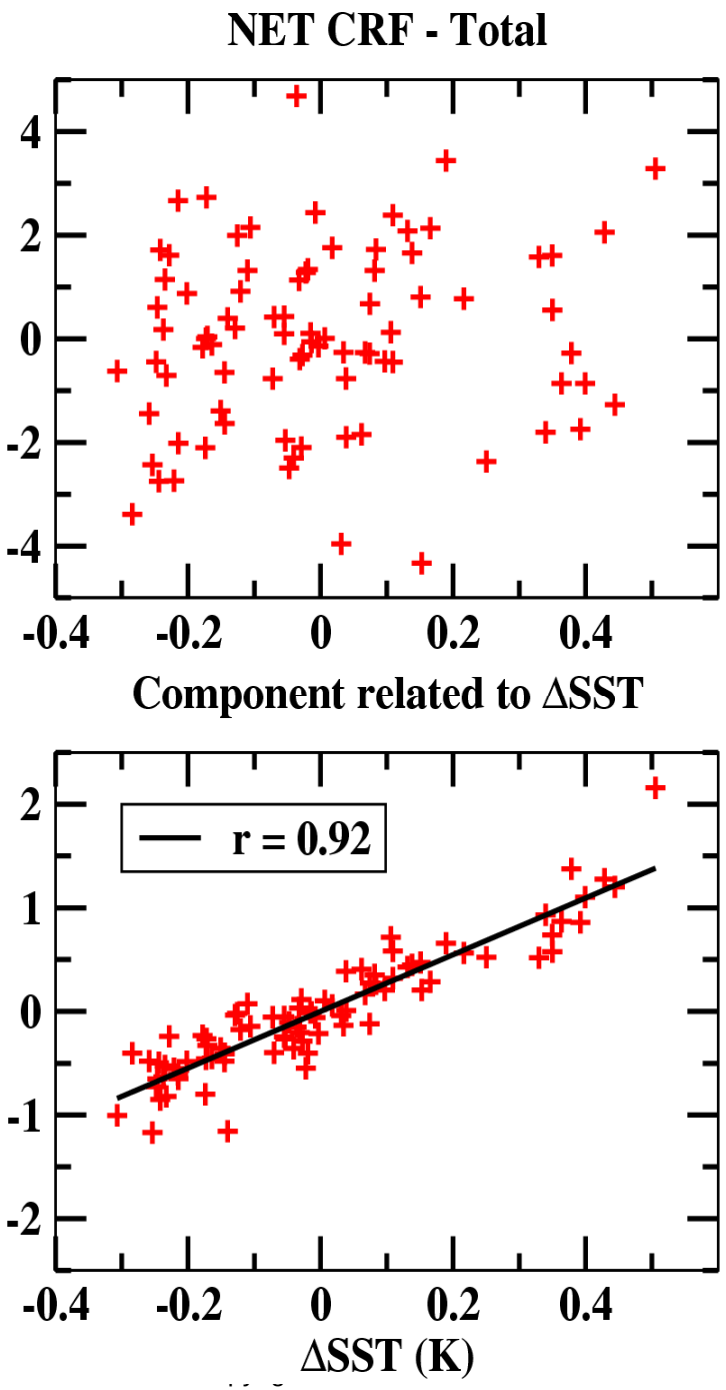




- Analogous to Bony et al (2004), Yuan et al (2008) construct time series of ω-SST CRF distributions
- Components of tropical mean CRF anomaly due to
  - *changes in CRF within the ω-SST bins*
  - *changes in the populations of the ω-SST bins*

Tropical Mean Net Cloud Forcing - ISCCP-FD





Component of CRF related to tropical mean anomaly in SST (Wm^{-2} K^{-1})

	NET	LW	SW
ISCCP	2.7 ± 0.1	2.2	0.5
ERBE	2.3 ± 0.1	2.0	0.3
MEAN	2.5 ± 0.1	2.1	0.4
HadCM3	2.7 ± 0.1	1.9	0.9
HadGEM1	2.8 ± 0.1	3.1	-0.3

- **Net warming response of clouds to tropical mean SST anomaly**
- **Remainder is due to local effects**
- **Could be used to evaluate climate models?**
- **Might be relevant to cloud feedbacks?**

Summary

- **Largest interannual variability in NET CRF occurs in areas of low cloud – consistency between ISCCP-FD, ERBE & CERES**
- **Variability in CRF is related to both large-scale and local changes in SST/circulation**
- **Variability in low cloud areas seems to be primarily related to local SST changes**
- **It may be possible to determine a component of the tropical mean CRF variability that depends on the tropical mean SST change**

Recap: definition of CRF

To a first approximation:

$$CSW = A_C \cdot (S_{clear} - S_{cloudy})$$

$$CLW = A_C \cdot (F_{clear} - F_{cloudy})$$

To first order $N = CSW/CLW$ is independent of cloud amount A_C (Cess et al 2001)

$\Delta CSW/\Delta CLW \sim N$ suggests cloud amount variations as primary driver of those in SW and LW CRF